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A Logical Model for the execution of Lean Product growth

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Abstract

Companies are faced with the need to address their product development challenges innovatively in order to stay competitive in today's market. One way of doing that is the integration of lean thinking in their product development process. However, due to the lack of clear understanding of the lean thinking performance measurements, the near absent of a holistic and unifying measuring method and the near or non-existence of an evaluating conceptual model to allow for the evaluation of the performance of the lean product development processes, many companies are unable to fully implement the lean thinking principle in their Product development process. In dealing with these issues, this study has therefore proposed a conceptual model which is based on some core critical success factors for the examination of lean performance in the product development process.

Keywords: *Lean product growth; Lean practices; Logical model; significant success factors.*

Introduction

Lean thinking which is an improvement philosophy was first developed by the Toyota Motor Company, primarily to eliminate waste from the production system. However, in recent years, these thinking have been extended to other areas including the product development process. According to Paschkewitz (2011), applying lean thinking practices in new product development can help save the huge resources normally spent fighting sudden quality and reliability issues, it can lead to faster product development and cycle time, reduction in warranty costs, easier and cheaper manufacturing processes. Also, it can result in high-quality suppliers products since the suppliers are involved in the development process of the product, as well as increase sales due to reliability in the products by customers, and finally it can create an atmosphere and culture of doing things right the first time.

Despite the many benefits and high hopes in the lean strategy, many companies are still struggling, and unable to neither achieve nor sustain substantial positive results with their lean implementation efforts (Aikhuele & Turan, 2016b; Stenius, 2011). In the work by León & Farris (2011), they suggested that, one of the major issue affecting the efficient administration and implementation of lean product development practices in companies lies in the absent of a unified and holistic model for assessing the performance of lean product development practices and in tracking their progress as they seek to achieve efficient and effective lean product development process executions. Letens et al., (2011), claim the poor implementation of lean product development practices is due to the lack of clear understanding of lean practices and their characteristics. While Stenius (2011) concluded that, the lack of lean thinking when implementing lean is the main issue affecting the efficient administration and implementation of lean product development practices, and proposed a framework for the prioritization of lean development actions.

However, as the first step towards addressing these issues, this paper seeks to propose a conceptual model for the implementation of lean product development in an automotive related company by considering the Critical Factors for the successful implementation of the lean thinking practices in the product development process and to provide a guide for determining the underlying relationship between these factors and develop a strategies for the successful implementation. The study is aimed at providing a roadmap for product development managers on the lean implementation route, and to assist them to lead their department as well as the entire organization to leanness.

This study technically contributes to process improvement of decision making, modelling, analysis of lean product development practices and the identification and analysing of the critical success factors for lean product development implementations.

The rest of the paper is organized as follows. The following section presents the literature review, critical success factors analysis and literature, the conceptual model and implication of the new model to Engineering Managers.

Lean product development framework

Over the last two decades, several papers including the theoretical and practical aspects of the lean product development practices have been published, where some have focused on defining the lean product development (Hoppmann, Rebentisch, Dombrowski, & Zahn, 2011; Ms Khan & Al-Ashaab, 2013) other has concentrated on constructing implementation and support models and frameworks that include steps and tools for the implementation of lean product development practices. The focal point of some of models and frameworks has been the development of tools and operational components, the models and frameworks are reviewed here.

Furuhjelm et al., (2011), provides input to a generic Lean Product Development framework by defining an explanatory model for effective knowledge enhancement and execution of development projects. The model which consist of a two by two matrix, with value streams, Product Value Stream and the Knowledge Value Stream at one hand, product and the Concept phase and Implementation phase on the other hand serves as a basis for discussing how the Lean principles, Flow, Visualization, Standardization, and Continuous Improvement could be implemented. Wasim et al., (2013) develop a cost modelling system for lean product and process to support a proactive decision-making process as well as in the elimination of mistake in the design stage using lean enablers like the set-based concurrent engineering, mistake proofing (Poka-yoke) and knowledge-based engineering. Al-Ashaab et al., (2010) develop a conceptual model and it'sassociated tools which are based on some core lean thinking enablers, which serve to provide knowledge-based user-centric design and development environment to support value creation to customers in terms of innovation and customization.

Nepal et al., (2011), through a reflective case study of a lean product development presented a lean transformation framework which was based on 13 lean principles of the Toyota Product Development System and it was implemented in a manufacturing firm in the US, using design structure and cause and effect matrixes for the analysis of the lean transformation and to determine the root causes of wasteful reworks in the company. Hines et al., (Hines, Francis, &

Found, 2006) propose a six-step theoretical framework that they hope could serve as a reference point for academic discussion on the development of systemic approaches to the lean product development process, as well as for industry searching for a framework in their new product development process.

Letens et al., (2011), propose a multilevel framework which captures key lean product development principles at the functional, project, and portfolio levels; tools and practices for implementing the lean product development practices at each level; and also discuss the approaches for managing the interactions between levels. Saad et al. (2013), presents a new approach, A3 thinking approach for solving problems in the product design process. Narayanamurthy (2014), presents the 7A process selection model for guiding the identification and selection of a suitable process for lean implementation. Parry & Turner (2006), develop a lean visual process management tools which serve as communication aids and are used to drive operations and processes in real time. Wang et al. (2012), presents a step-by-step implementation framework for lean product development starting from the marketing research on the product development process, product design through to the launch of the final product, where the framework was aimed at overcoming the weaknesses in the existing framework in terms of reliability and feasibility. Khan (2012), presents an innovative model for supporting the implementation of lean thinking in the product development environment, where the model provides a process for the conceptual development of an engineering project and it composed of phases and activities for which methodologies is defined.

Even with a large number of proposed models and frameworks for implementing lean in the product development process, none of the existing models and frameworks accounts for the critical success factors that can lead to lean product development performance. Critical success factors have a key role in the successful implementation of lean product development as well as any other improvement methodology.

After extensive literature review to identify the critical success factors that can lead to successful lean product development implementation, seven (7) main factors have been identified for successful implementation of lean product development and are explained in the following section. These factors have been summarized in Table 1 along with their literature support.

Table 1. Critical success factors in the literature

	Lean product development practices	Literature support
(1)	Set-based concurrent engineering	(Al-Ashaab et al., 2015; Ms Khan & Al-Ashaab, 2013; Muhammad Khan et al., 2011; Raudberget, 2011).
(2)	Strongproject manager	(Al-ashaab, Andino, & Summers, 2013; Al-Ashaab et al., 2015; Ms Khan & Al-Ashaab, 2013).
(3)	Cross-functional teams	(Cooper & Kleinschmidt, 2007; Kim & Kang, 2008; Sethi & Al., 2001).
(4)	Supplier integration	(Aikhuele & Turan, 2016a; Echtelt & Wynstra, 2001; Petersen, et al., 2003, 2005)
(5)	Knowledge-based engineering,	(Corallo, Laubacher, Margherita, & Turrisi, 2009; Ms Khan & Al-Ashaab, 2013; Stenholm, Mathiesen, & Bergsjo, 2015; Verhagen, Bermell-Garcia, Van Dijk, & Curran, 2012)
(6)	Modularity	(Chen & Tan, 1994; Harland & Uddin, 2014; Pugh, 1996)
(7)	Visual management	(Carulli, Bordegoni, & Cugini, 2013; Jurado, 2012; Parry & Turner, 2006)

Critical Success Factors for Successful Implementation of Lean Practices during Product development

Strong Project Manager: The implementation of the lean practice in product development requires the use of a strong and experienced project manager. The task of the manager in this case, however, goes beyond the traditional sole management and integration of functions but rather unto conducting research and analysis of competitor products with the view to understanding the values of the customer. The Project manager is also responsible for the translation of the result of the research into a well-aligned goal for the different sectors involved.

Set-based concurrent engineering: The set-based concurrent engineering which is potentially one of the main underlying cause for the successes recorded by the Toyota Motor Company (Allen Ward, Jeffrey K. Liker, John J. Cristiano, 1995) is an organized group of principles that allows design practitioners to reason, develop, and communicate about a sets of solutions in parallel, and gradually narrow them down based on the knowledge and information gained through customers relations and interaction, communication with the manufacturing departments, tests/design of prototypes, and other sources. The set-based engineering as a lean enabler comprises of five different major perspectives; Strategic value research and alignment, Mapping the design Space, Creation and exploring of multiple concepts in parallel, Integrate by intersection and Establish feasibility before commitment.

Supplier integration: In the lean product design context, the suppliers of the parts for the manufacturing of the product are actively involved in all aspect of the PD, right from the early stages of the design through to the product launch, this is to avoid misunderstanding and rework, also, the involvement of the supplier in the PD process helps in speeding up the process. This is in contrast to the traditional product development practices where the suppliers only get involved when the detailed design specifications have been developed. Supplier integration as a lean enabler is based on the following; Supplier feedback, Supplier development, and Supplier support/involvement.

Knowledge-based engineering: Knowledge Based Engineering which is an innovative method allows businesses including design practitioners to capture product and process information and to reuses such information in automating all or part of the process. The main objective of this lean enabler is to reduce time to market for the new product and for the reduction of product development cost. This is achieved through the automation of repetitive design tasks while capturing, retaining and re-using of the gain design knowledge. The Knowledge Based Engineering as a lean enabler is based on the following; Knowledge Identification, Knowledge Representation, Knowledge Capturing and Knowledge Re-Use.

Cross-functional teams: The cross-functional team is a business practice where a group of experts from different section/units with different functionality in a company are brought together to work as a team towards a common goal.

Modularity: Modularity in the product design and development environment is a practice where large product components are built by combining smaller sub-product components. This practice is directly related to product development tools like Design For 'X', Design for Service Design for Assembly, Design for Six Sigma, Design for Disassembly, Design for Environment etc.

Visual management: Visualizations in product design are mainly related to the communication of products and design concepts. The visualization concept helps in supporting product managerial tasks at the early product design phase and plays a key role in supporting communication between cross-functional teams. The visual management practice help in detecting errors at the source and ensure they don't go farther in the development stage, Examples of this practice includes, the parametric systems in CAD, detailed and standardized test plans, checklists etc.

Conceptual Model

The introduction of lean thinking in the product design and development environment provides a knowledge-based support for value creation for customers by considering the entire product life cycle. The new model draws insights partly from the lean product development conceptual model developed by Al-Ashaab et al. (2010). The following will proceed to represent the lean product development conceptual model taking into account the identified crucial factors for the successful implementation of lean product development as shown in **Figure 1**.

The Hypotheses regarding the model has been listed below:

- Visual management affects the implementation of lean product development.

- Modularity affects the implementation of lean product development.
- Set-based concurrent engineering affects the implementation of lean product development.
- Knowledge-based engineering affects the implementation of lean product development.
- Supplier integration affects the implementation of lean product development.
- Cross-functional team affects the implementation of lean product development.
- Strong project manager affects the implementation of lean product development.

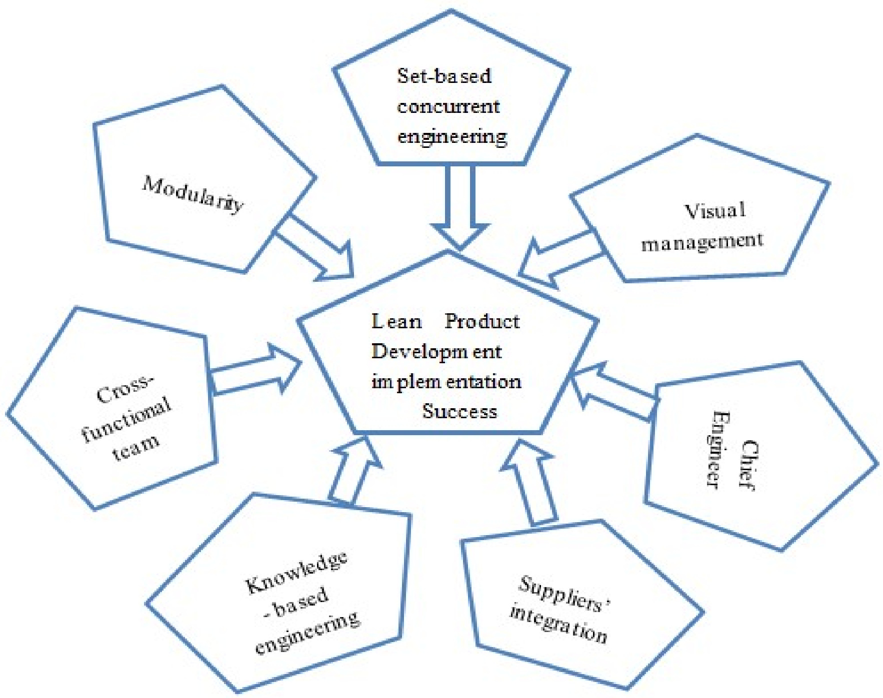

Figure 1: Lean product development implementation conceptual model

Although each of the lean practice in the model has been described and discussed individually, the lean product development conceptual model is assumed to be an open system with functional relationships among its features and can lead to mutual adjustments and interaction among the practices.

As seen from the reviewed literature, none of the published work on lean product development has attempted to link the lean product development process to the lean performance such as in the area of assessment and planning. Likewise, research on generic lean practices in the product development (Al-ashaab et al., 2013; Badizadeh & Khanmohammadi, 2011; Graebsch, Seering, & Lindemann, 2007; Lolas, Olatunbosun, Steward, & Buckingham, 2007; Sopelana, Flores, Martinez, Flores, & Sorli, 2012; Vladu, Dobre, & Miric, 2013) has focused primarily on the lean practices and its performance with no regards to the relationships and interactions between the lean practice performance and other features such as the capacity of the practice. While other researchers have concentrated on the financial aspect of the performance (Ahmad, 2012; Kaplan & Norton, 1992; Wasim et al., 2013) and mostly didn't consider the relationship and interactions between these financial aspects and actual lean practice performance.

Nevertheless, it is likely that the explication of the conceptual model for the lean product development as proposed herein will serve as a basis for measuring lean product development performance, and will encourage researchers to further examine in details the relationships and interactions between the different lean practices in the model. Similarly, the model could serve as a support base for performance management as well as improvement efforts in the implementation of the different lean practice, also, it could facilitate continuous learning, generation of systematic and rigorous findings about implementation of the lean product development, as well as addressing the confusion and inconsistency associated with the lean performance measurements.

Conclusion

The paper presents a practical, agreeable and critical evaluating conceptual model that represents all aspect of the lean product development under a common platform and stands as a unifying and a holistic model for the evaluation of all aspects of the lean product development process. The proposed conceptual model which is based on the critical success factors explicates the relationships between the lean product development process and the lean performance and serves as a guide for the development research tools and strategy for monitoring the lean product development, as well as in the improvement of the product development process.

The model we hoped will allow lean product development researchers and practitioners to effectively examine the relationship between the lean product development process and the lean performance; also, it will facilitate continuous learning, the generation of systematic and rigorous findings about the implementation of the lean product development as well as contributing to the development of the lean product development performance system.

Implications for Engineering Managers

The conceptual model derived from this research could reduce the misunderstanding and ambiguity in the lean performance measurements as well as provide a holistic and a unifying measuring method for all the critical aspects of the lean product development process. The article highlights some critical success areas as it relates to performance measurement at the early stage of the product development phase through which the lean product development progress can be tracked, uncertainty in the design and development process measured as well as in the reduction of product design and development risk.

Practicing engineering managers, most especial those involve in the development of new product or in the modification of existing products will found this research very useful as its provides the foundation for the development of a unifying performance-based model for the holistic evaluation of the lean product design and development performance at the early stage of product design as well as providing a base for the study and assessment of lean product design and development process.

References

Ahmad, W. (2012). *Cost modelling system to support lean product and process development. PhD Thesis.*

Aikhuele, D. O., & Turan, F. M. (2016a). A Hybrid Fuzzy Model for Lean Product Development Performance Measurement. *IOP Conference Series: Materials Science and Engineering*, *114*(1), 012048. http://doi.org/10.1088/1757-899X/114/1/012048

Aikhuele, D. O., & Turan, F. M. (2016b). Proposal for a Conceptual Model for Evaluating Lean Product Development Performance: A Study of LPD Enablers in Manufacturing Companies. *2Nd International Manufacturing Engineering Conference and 3Rd Asia-Pacific Conference on Manufacturing Systems (Imec-Apcoms 2015)*, *114*. http://doi.org/10.1088/1757-899X/114/1/012047

Al-ashaab, A., Andino, A., & Summers, M. (2013). Lean product development performance measurement tool. *Proceedings of the 11th International Conference on Manufacturing Research (ICMR2013) Advances in Manufacturing Technology XXVII: 19-20 September 2013. Cranfield, Bedfordshire, UK.*, (September), 19–20.

Al-Ashaab, A., Golob, M., Urrutia, U. A., Gourdin, M., Petritsch, C., Summers, M., & El-Nounu, A. (2015). Development and application of lean product development performance measurement tool. *International Journal of Computer Integrated Manufacturing*, (October), 1–13. http://doi.org/10.1080/0951192X.2015.1066858

Al-Ashaab, A., Shehab, E., & Alam, R. (2010). The conceptual LeanPPD model. In *Proceedings of the 17th ISPE International Conference on Concurrent Engineering. Krakow, Poland, September 6-10, 2010.* (pp. 303–310). http://doi.org/10.1007/978-0-85729-024-3-33

Allen Ward, Jeffrey K. Liker, John J. Cristiano, D. K. S. I. (1995). The second toyota paradox: how delaying decisions can make better cars faster. *Sloan Management Review*, *36*(January), 43–61. http://doi.org/10.1016/0024-6301(95)94306-J

Badizadeh, A., & Khanmohammadi, S. (2011). Developing a Fuzzy model for assessment and selection of the best idea of new product development. *Indian Journal of Science and Technology*, *4*(12), 1749–1762. Retrieved from internal-pdf://29-dec11ali-0837319183/29-dec11ali.pdf\nhttp://indjst.org/current/29-dec11ali.pdf http://indjst.org/archive/vol.4.issue.12/29-dec11ali.pdf

Carulli, M., Bordegoni, M., & Cugini, U. (2013). An approach for capturing the Voice of the Customer based on Virtual Prototyping. *Journal of Intelligent Manufacturing*, *24*, 887–903. http://doi.org/10.1007/s10845-012-0662-5

Chen, S.-M., & Tan, J.-M. (1994). Handling multicriteria fuzzy decision-making problems based on vague set theory. *Fuzzy Sets and Systems*, *67*(2), 163–172.

Cooper, R. G., & Kleinschmidt, E. J. (2007). Winning Businesses in Product Development: the Critical Success Factors. *Research Technology Management*, *50*, 52–66. Retrieved from http://www.scopus.com/inward/record.url?eid=2-s2.0-34249046072&partnerID=40&md5=a4f69c645cc4949765fb19b82d5be0f9

Corallo, A., Laubacher, R., Margherita, A., & Turrisi, G. (2009). Enhancing product development through knowledge-based engineering (KBE): A case study in the aerospace industry. *Journal of Manufacturing Technology Management*, *20*, 1070–1083. http://doi.org/10.1108/17410380910997218

Echtelt, F. Van, & Wynstra, F. (2001). Managing supplier integration into product development: a literature review and conceptual model. *The Future of Innovation Studies*, 1–22. Retrieved from http://cms.tm.tue.nl/Ecis/Files/papers/wp2002/eciswp55.pdf

Furuhjelm, J., Swan, H., & Tingström, J. (2011). Creating Value Through Lean Product Development – Applying Lean Principles. *Development*, *3*(August).

Graebsch, M., Seering, W. P., & Lindemann, U. (2007). Assessing Information Waste in Lean Product Development. *Proceedings of the International Conference on Engineering Design (ICED)*, (August), 1–12.

Harland, P. E., & Uddin, Z. (2014). Effects of product platform development: fostering lean product development and production. *International Journal of Product Development*, *19*(5), 259–285. http://doi.org/10.1504/IJPD.2014.064881

Hines, P., Francis, M., & Found, P. (2006). Towards lean product lifecycle management: A framework for new product development. *Journal of Manufacturing Technology Management*, *17*(7), 866–887. http://doi.org/10.1108/17410380610688214

Hoppmann, J., Rebentisch, E., Dombrowski, U., & Zahn, T. (2011). A Framework for Organizing Lean Product Development. *Engineering Management Journal*, *23*(1), 3–16.

Jurado, M. C. (2012). Visual Planning in Lean Product Development. *Master Thesis*.

Kaplan, R. S., & Norton, D. P. (1992). The Balanced Scorecard - Masures That Drive Performance. *Harvard Business Review*, *70*, 71–79.

Khan, M., & Al-Ashaab, A. (2013). Towards lean product and process development. *International Journal of Computer Integrated Manufacturing*, *26*(12), 1105–1116. Retrieved from http://www.tandfonline.com/doi/abs/10.1080/0951192X.2011.608723

Khan, M., Al-Ashaab, A., Doultsinou, A., Shehab, E., Ewers, P., & Sulowski, R. (2011). Set-based concurrent engineering process within the LeanPPD environment. *Advanced Concurrent Engineering*, (July), 433–440. http://doi.org/10.1007/978-0-85729-799-0_51

Khan, M. S. (2012). *The construction of a model for lean product development*. *Cranfield Univeristy*. Retrieved from http://search.proquest.com/docview/1557535531?accountid=8144\nhttp://sfx.aub.aau.dk/sfxaub?url_ver=Z39.88-2004&rft_val_fmt=info:ofi/fmt:kev:mtx:dissertation&genre=dissertations+&+theses&sid=ProQ:ProQuest+Dissertations+&+Theses+Global&atitle=&title=The+

Kim, B. Y., & Kang, B. K. (2008). Cross-functional cooperation with design teams in new product development. *International Journal of Design*, *2*(3), 43–54.

León, H. C. M., & Farris, J. A. (2011). Lean Product Development Research: Current State and Future Directions. *Engineering Management Journal*, *23*(1), 29–51. http://doi.org/10.1080/10429247.2011.11431885

Letens, G., Farris, J. a, & van Aken, E. M. (2011). A Multilevel Framework for Lean Product Development System Design. *Engineering Management Journal*, *23*(1), 69–85. Retrieved from http://0-search.ebscohost.com.aupac.lib.athabascau.ca/login.aspx?direct=true&AuthType=url,ip,uid&db=bth&AN=59856025&site=ehost-live

Lolas, S., Olatunbosun, O. A., Steward, D., & Buckingham, J. (2007). Fuzzy Logic Knowledge Base Construction for a Reliability Improvement Expert System. In *Proceedings of the World Congress on Engineering 2007 Vol I WCE 2007, July 2 - 4, 2007, London, U.K.* (Vol. I, pp. 2–7).

Mohd Saad, N., Al-Ashaab, a., Maksimovic, M., Zhu, L., Shehab, E., Ewers, P., & Kassam, a. (2013). A3 thinking approach to support knowledge-driven design. *International Journal of Advanced Manufacturing Technology*, *68*, 1371–1386. http://doi.org/10.1007/s00170-013-4928-7

Narayanamurthy, G. (2014). 7A Model - A Process Selection Guide for Lean Implementation. In *Proceedings of the Twenty Fifth Annual Conference Production and Operations Management Society (POM 2014), 9-12 May 2014, Atlanta, USA.* (pp. 1–13).

Nepal, B. P., Yadav, O. P., & Solanki, R. (2011). Improving the NPD Process by Applying Lean Principles: A Case Study. *Engineering Management Journal*, *23*(3), 65–81. http://doi.org/10.1080/10429247.2011.11431886

Parry, G. C., & Turner, C. E. (2006). Application of lean visual process management tools. *Production Planning & Control*, *17*(1), 77–86. http://doi.org/10.1080/09537280500414991

Paschkewitz, J. J. (2011). Ensuring Reliability in Lean New Product Development.

Petersen, K. J., Handfield, R. B., & Ragatz, G. L. (2003). A model of supplier integration into new product development. *Journal of Product Innovation Management*, *20*, 284–299. http://doi.org/10.1111/1540-5885.00028

Petersen, K. J., Handfield, R. B., & Ragatz, G. L. (2005). Supplier integration into new product development: Coordinating product, process and supply chain design. *Journal of*

Operations Management, *23*, 371–388. http://doi.org/10.1016/j.jom.2004.07.009

Pugh, S. (1996). *Creating innovative products using total design: The living legacy of Stuart Pugh*. *Reading, MA: Addison-Wesley*.

Raudberget, D. S. (2011). Enabling Set-Based Concurrent Engineering in Traditional Product Development. *Proceedings of the 18th International Conference on Engineering Design (ICED11), Vol. 1*, (August), 45–56. Retrieved from http://papers.designsociety.org/enabling_set-based_concurrent_engineering_in_traditional_product_development.paper.30406.htm

Sethi, R., & Al., &. (2001). Cross Functional Product Development Teams Creativity and Innovativeneness of ?ew Consumer Products. *Journal of Marketing Research*, *XXXVIII*(Febuary), 73–85. http://doi.org/10.1509/jmkr.38.1.73.18833

Sopelana, A., Flores, M., Martinez, L., Flores, K., & Sorli, M. (2012). The Application of an Assessment Tool for Lean Product Development : An exploratory study in Spanish Companies. *International Conference on Engineering, Technology and Innovation*, 1–10.

Stenholm, D., Mathiesen, H., & Bergsjo, D. (2015). Knowledge Based Development in Automotive Industry Guided by Lean Enablers for System Engineering. *Procedia Computer Science*, *44*, 244–253. http://doi.org/10.1016/j.procs.2015.03.047

Stenius, P. (2011). Making lean work leaner by prioritizing actions and moving promptly into implementation. *Reddal-BusinessDeveloperNewsletter*, pp. 1–8.

Verhagen, W. J. C., Bermell-Garcia, P., Van Dijk, R. E. C., & Curran, R. (2012). A critical review of Knowledge-Based Engineering: An identification of research challenges. *Advanced Engineering Informatics*, *26*(1), 5–15. http://doi.org/10.1016/j.aei.2011.06.004

Vladu, M. R., Dobre, G., & Miric, R. F. (2013). Application of the fuzzy logic in the evaluation of solution variants in the product development process. *1ssn 1454-234x*, *75*(1).

Wang, L., Ming, X. G., Kong, F. B., Li, D., & Wang, P. P. (2012). Focus on implementation: a framework for lean product development. *Journal of Manufacturing Technology Management*, *23*, 4–24. http://doi.org/10.1108/17410381211196267

Wasim, A. A., Shehab, E., Alam, H., Al-Ashaab, A., & Sulowski, R. R. (2013). An innovative cost modelling system to support lean product and process development. *Int J Adv Manuf Technol*, *65*, 165–181.